LAGNITON

Methods of Preserving Timber

Civil Engineering

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METHODS OF PRESERVING TIMBER

BY

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This is to certify that the thesis of ISABELO LAG-NITON entitled Methods of Preserving Timber is approved by me as meeting this part of the requirements for the degree of Bachelor of Science in Civil Engineering.

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METHODS OF PRESERVING TIMBER.

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I. INTRODUCTION.

Wood is one of the most important and useful of engineering materials whose cost is a big sum to everyone who must use timber where it is likely to decay. The constant increase in the demand for wood, which in many regions, is not met by forest growth, leads to a steady rise in the price of lumber. How to reduce the cost of wood used in any engineering work is one of the most vital problems which engineers of today have to solve, and in fact, for a number of years past, engineers have been compelled to give serious considerations to reducing the price of timber.

Census statistics show that in 1907 the steam and electric railroads purchased 153,000,000 cross ties; the telephone, telegraph, and other electric companies purchased over 3,000,000 poles, and it is estimated that 170,000,000 cu. ft. of round timber were used in the mines throughout this country, and at least 2,000,000,000 feet were used in piling. United States uses one hundred billion feet board measure of timber every year. This amount of consumption is very large compared with the annual growth of all the forests in this country (which does not exceed over 35 billion ft.). It is clear that, excluding the annual growth, the total amount of timber consumed would be sufficient to exhaust the forests in this country in a few years. Thus it is indispensable that other materials to act as substitutes should be developed. The life of the forest should be extended, and that the life of timber in service should be prolonged by the use of wood preservative processes. It is with these processes that this thesis is to deal.

II. CAUSES OF DECAY IN TIMBER.

The decay of wood is caused by the growth of low forms of plant life known as bacteria and fungi, and by the presence of some boring animals such as white ants, worms and teredos.

Wood is composed of a mass of united bodies called cells. Cell wall is made up chiefly of a substance called cellulose and around of which are coated different substances known as lignum. The cellulose and the lignum are used by the fungi for food or are changed in composition by certain substance in fungi. Thereby causing the wood to become brittle and of less strength and finally producing decay.

III. HOW TO PROLONG THE LIFE OF TIMBER IN SERVICE.

There are three general methods of wood preservation, namely:

A. Seasoning

B. Chemical Impregnation

1. Open tank or non-pressure process
2. Closed tank or pressure process

C. Mechanical Devices.

By seasoning timber is meant taking out or reducing the moisture in the wood which affords a sheltering place for the growth of fungi and which prevents the entrance of chemical preservation. The following are the three ways of seasoning timber.

1. Air seasoning.
2. Steaming.
3. Oil seasoning.

Air seasoning is accomplished by keeping the wood in a storage place for a certain length of time. Great care should be taken in piling the wood so as to allow free access of air. The quantity of moisture reduced is dependent upon the place, climate, and the duration of treatment. Air seasoning is recognized as being the superior method of driving out the moisture when the wood structure is not dense. The chief objection to this process is that it is very slow, and if the timber is not properly piled, and is held for a long period in a seasoning yard it is liable to decay especially in a place where atmospher is warm and damp.

The steaming process is well adapted to seasoning

green timber, and it is an indispensable device, preparatory to the preservative treatment of wood whose structure is dense. Saturated and superheated steam are used in this process. Timbers are first placed in tight cylinders and are subjected to a partial vacuum, after which the live steam of 30 lbs. is admitted and is maintained for four hours. Then a second vacuum is produced which removes the moisture out of the wood.

Oil seasoning is accomplished by heating the wood in the oil at a temperature above that of the boiling water. By this means, the wood decreases in weight on account of the sap and water being vaporized and driven off. Oil seasoning will soon come into general use, and it is especially adapted as a preparatory device to the preservative treatment by the open tank process.

B. Chemical Impregnation.

Decay of timber as already described is caused by the presence and development of fungi in the wood. Hence to prevent the growth of this low form of plant life, poisonous substances are injected into the wood, thereby depriving the fungus of its food. This method of preserving timber is called Chemical Impregnation.

1. Open Tank Process.

This is the non-pressure process of preserving timber. It was successfully brought before the public in 1867 by Professor Charles A. Seely of New York. This method found no possibility of its commercial application until the United States Forest Service of Agriculture carried on tests at the Louisiana Purchase Exposition in 1904.

In this process, impregnation with a preservative is accomplished by heating the air and moisture in the wood, and then it is allowed to cool. By so doing a vacuus condition is produced, which is destroyed by the entrance of the preservative. The duration of treatment depends upon the character of the wood and the amount of strength desired. Then the timber is either transfered to another tank containing cool preservative or is allowed to remain in the tank with the heat shut off or the hot liquid is allowed to run into underground tanks through large pipes and a cooler preservative is admitted almost simultaneously. A cu. ft. of seasoned loblolly pine which is made up of solid liquid and air, weighs 35 lbs. Without gas and sap it weighs 30 lbs.

When it is desired to impregnate the wood with an aqueous solution such as zinc chloride, the wood is first heated in oil and then it is submerged in cold water solution. Poles treated in this manner in which the penetration of zinc chloride is four inches, has an absorption varying from $\frac{1}{2}$ lb. to 2 lbs. per cu. ft. This amount depends largely upon the strength of the solution and the duration of the hot and cold baths.

There are two general types of open tank plants in use. In one the wood is moved during the baths while in the other the preservative is moved. The former is the simpler type and the one best suited to the treatment of fence posts and other small timbers and where a small amount of wood is to be treated. Round timbers such as posts, poles, props, etc. are successfully treated by this process. Its advantage of significant value is that it enables the treatment to be adapted in accordance with the conditions to which the wood will be subjected.

(1) Kyanizing.

This process was introduced in 1832 by Howard Kyan. The timber is steeped in a solution of bichloride of mercury, the most powerful antiseptic known next to creosote. Usually the duration of treatment depends upon the least thickness of the wood, and the degree of absorption depends upon the length of time and the resistance of the cells of the wood.

Originally the degree of dilution used was one pound of dry salt to four gallons of water, but later it was reduced to one pound of dry salt to fifteen gallons of water. From this method of treatment, it has been found out that at Lowell, Mass., a platform of kyanized timber built over the water showed no indication of decay after forty-five years in service. The Blackstone river bridge on the New York and New England R. R. was still undecayed after an exposure of twenty-eight years. For this method there is claimed an advantage over the Burnettizing process in that the former does not weaken the timber and it is very efficient for treating materials which do not come in contact with the earth.

2. The Closed Tank Method.

This method of preserving wood is known as the vacuum or pressure process. This differs from the open-tank process in that in the former the sap is taken out by exhausting the air in a closed tank and the chemical preservative is injected into the wood under high pressure, or the wood is filled with compressed air before the preservative solution is forced into the cylinder. This method of preservative is divided into several different processes, namely:

1. Burnettizing
2. Wellhouse and Allardyce Processes
3. [illegible]-Resinate Process
4. Creosoting
5. Copper-Sulphate
6. Neutral Processes.

(1) Burnettizing Process.

This process was brought before the public in 1838 by Sir William Burnett. It consists of injecting into the wood zinc chloride dissolved in water, thereby preventing the attacks of fungi and wood boring insects. The solution which has proved satisfactory is 1 part of zinc chloride to 75 parts of water. Railroad ties which have been treated by this process were found to be almost undecayed after sixteen years in service. Burnettizing has the great advantage of being cheap and on this account it has been used extensively for the last few years.

(2) Wellhouse and Allardyce Processes.

Several modifications to the Burnettizing method have been accomplished such as the Wellhouse's process in which a small amount of glue is added to the solution of zinc chloride, and it is followed by a solution of tannin, the purpose being to close the pores in the wood in order to retain the zinc chloride. Another modification is called the Allardyce Method which was introduced by the International Creosoting Company of Galveston, Texas. In this process a solution of 3 per cent of zinc chloride in proportion of twelve pounds to the cu. ft. is first injected into the wood. Then it is followed by a second injection of dead oil of coal tar whose proportion is three lbs. to the cubic foot. The object of this method is to produce a waterproof coating around the outer surface of the wood. It is very well adapted for treating ties, poles, and other materials which come in contact with the earth.

(3) Creo-resinate Process.

In this process the wood to be treated is first seasoned by using a dry heat at a temperature of 250° F. This heat is maintained until the temperature of the center of the block reaches 212° F. Having lowered the temperature to 150° F. a vacuum of 26 inches is produced. The cylinder is then filled with creo-resinate solution which consists of 50 % of creosote oil and 50 per cent resin. Upon applying the pressure the mixture is forced into the wood and this force is maintained until the amount of absorption is twenty-two pounds per cubic foot. After this the wood is treated with lime having a temperature of 212° F., and is subjected to a pressure of 150 lbs. to the sq. in. and finally is allowed to cool. This method of preservation has been used by the U. S. Wood Preserving Co. of New York, and it is very well adapted to the treatment of the wooden blocks used for pavements.

(4) Creosoting. Rueping Process.

The most efficient method known for preserving timber is creosoting. It was invented by John Bethell in 1838. The new process now used differs from the old system in that in the former the creosote oil is forced into the wood under pressure where as in the latter it is forced under a vacuum. The first operation in the Rueping process is that the seasoned timber is placed in the impregnating cylinder and the pressure cylinder is filled with creosote oil and then both are subjected to a pressure of 75 lbs. per sq. in. which takes about half an hour. The creosote oil in the impregnating cylinder is allowed to flow by gravity in-

to the pressure cylinder until the latter is full. The pressure is then raised to 170 lbs. and is maintained for fifteen minutes. After the timber is thoroughly saturated with preservative the pressure is released thereby the compressed air inside the wood expands and forces out the surplus of the chemical preservative which is allowed to flow by gravity into an underground tank. In order to further remove the oil which still remains around the outside pores of the wood a vacuum of 22 inches is created and is maintained for a few minutes. Having this oil removed the charge is withdrawn. The whole series of operation requires about four hours and twenty minutes.

The new and unique process of creosoting which has been introduced by the Santa Fe R. R. in Texas, differs from the one already described in that in the former the air-seasoned wood is first subjected to a pressure of 5 atmospheres and then the oil is forced into the impregnating cylinder by means of a higher pressure of 15 atmospheres, while in the latter the oil is allowed to run into the cylinder by gravity. From the results obtained by the use of creosoting process, it has been found that it is one of the best means of getting rid of the most dangerous attacks of the wood boring animals.

a. Specifications of Creosote Oil.

From the result of recent investigation on creosote oil, conclusions has been brought forward that the actual chemical composition of the constituents of dead oil of coal tar is of minor importance in securing the indefinite preservation of timber. The following are the requirements upon which the creosote oil be based:

1. The oil shall be the best grade of coal tar; it shall be free from the admixture of petroleum oil and other substances foreign to the pure coal tar; and it must be free from suspended matter.

2. The specific gravity of the oil shall be at least 110 at 25° C. and 1.03 at 38° C.

3. It shall be a complete liquid at 100° F. and it must remain so in cooling down to 90° F.

Before the oil is used it shall be subjected to the following test:

Use an eight ounce retort covered with asbestos. Place the bulb of the thermometer one half inch above the liquid in the retort. Place 100 grams of oil in the retort and insert the thermometer in the retort with the lower end of the bulb one half inch from the surface of the oil. The condensing tube shall be attached to the retort by a tight cork joint and the distance between the bulb of the thermometer and the condensing tube shall be twenty-two inches. The tube shall be subjected to a gradually increasing heat with a Bunsen burner. The quantity of oil collected shall be compared with the dry oil and the total amount shall not exceed the following:

Up to 170° C. no distillate
" " 210° C. not more than 5 % must come off
" " 235° C. " " " 20 % " " "
" " 315° C. " " " 40 % " " "

The solid residuum above 355° C. should not be more than 4%.

Source: The Atchison, Topeka & Santa Fe Ry. Co., Somerville, Texas.

The following is a test of evaporation and volatility of creosote oils of different specific gravity.

50 grams of each oil were placed in a cylindrical vessel 3 inches in diameter and $1\frac{1}{4}$ inches in height. The oil was subjected constantly to a temperature of 120° F. for a period of 50 days, and it was frequently weighed.

Creosote Oils		Distillate			
Number of Samples Used	Specific Gravity	To 315°C Per Cent	315°-317°C Per Cent	Total to 370°C Per Cent	Residue Per Cent
s - 997	1.055	82.5	8.5	91.0	9.0
s - 1003	1.120	33.4	13.4	46.8	53.2
s - 1008	1.065	83.1	8.5	91.6	8.4
s - 1017	1.190	35.4	10.9	46.3	53.7

Creosote Oils.

Loss in Weight at 120° F.

No. of days	s - 997 Total Loss Per Cent	s - 1003 Total Loss Per Cent	s - 1008 Total Loss Per Cent	s - 1017 Total Loss Per Cent
1	13.3	6.2	10.9	3.8
2	20.2	8.1	18.2	5.7
3	26.8	10.7	24.2	7.4
6	41.1	13.3	39.1	9.9
10	53.1	16.0	49.7	12.1
15	58.9	18.1	54.4	15.0
22	63.4	19.1	59.1	15.8
29	67.0	19.6	61.9	16.2
36	69.1	20.5	64.1	16.7
43	70.9	20.8	66.1	17.3
50	72.3	21.2	67.5	17.6

From the results given above it is to be noted that the amount of oil evaporated or the total loss is very much less in the lighter oil than that in the heavier oil. Thus, when the loss is very great, according to what experience has shown, an additional amount of resin will result injurious rather than beneficial.

Authority - Geo. W. Tillson, Chief Engineer of Highways, Borough of Manhattan, N. Y.

(4) Copper Sulphate Process.

The procedure of this method of preserving timber is the same as the Creo-Resinate Process. It has been found out that copper sulphate process has very little value as a method of wood preservation. It is not extensively used in this country on account of the fact that the presence of iron and carbonic acid remove the copper very easily.

(5) Neutral Processes.

Several new processes, in which fluorides are used, have been introduced by Captain Malenkovic of the Austrian Army. He found that hydrofluoric acid and its salts destroy bacteria and fungi which cause the decay of wood. Various organisms which resisted the action of $3\frac{1}{2}$ per cent of zinc chloride and 4 per cent of copper sulphate, were killed by $\frac{3}{4}$ per cent of zinc fluoride or sodium fluoride and by $\frac{1}{4}$ of one per cent of hydrofluoric acid.

The most recently patented process of impregnating timber is called the natural processes. In this a mixed solution of zinc chloride and sodium fluoride are used. The result is that the basic fluoride of zinc is formed in the fiber of the wood and

on account of its insolubility and fungicidal power, it exerts a strong and permanent preservative action. This new method of preserving wood will soon come into extensive use, especially in building and mining construction, where creosote oil is objectionable on account of its offensive oder and its inflammability.

C. Mechanical Devices of Wood Preservation.

1. Teredo .

One of the Salt water boring mollusks which has caused a great destruction through wooden structures over salt water is the teredo. At an early stage of its growth, it is a free swimming animal and entering any wood work which may have been left exposed by a hole not larger than a pin head. After it has started its boring, it does not only grow in length but also in diameter, and it has been known to reach a diameter as large as ¾ of an inch. The teredo is whitish in color and is provided with two flexible tubes or siphons which extend into the water. It is from these organs and salt water that the teredo gets its nourishment. Thus, to cut off the wood from coming into contact with water, not only kills the teredo but also prevents other teredos from entering the wood.

2. The Seven Devices of Protecting Wood Piles from Salt Water Boring Mollusks.

(1) By driving thousands of round headed iron tacks into the pile. The work can only extend from the low water upward unless a driver is employed. This method is very slow and does not protect the wood entirely for which account it is not used extensively.

(2) The copper sheathing method is a good protection. But copper is liable to corrode in salt water at the joints and around the nail heads. The expense in this process is apt to be very

heavy. This is due to the fact that the exact depth to which the pile is to be driven is not always known in advance and hence the upper covering is likely to be made to extend either too close to the bottom of the pile where it is unnecessary in the mud or too close toward the top of the pile where it is useless above the high water line.

(3) Tar burlap is used to wind spirally around the pile. It is not a good protection on account of other materials floating down stream tend to tear the protection. Furthermore after the tar is more or less covered with weeds, barnacles and oysters cling to the material and they tend to pull away the burlap, thereby leaving the pile exposed at the top. In driving the pile the tar burlap has difficulty in penetrating the mud line and hence as it recedes the pile is left exposed at the bottom.

(4) As a coating around the piles concrete has been used. Molds are being placed by the divers and the concrete is poured. The great difficulty met in this method is the tendency of the mixture to weaken as it is poured down through the water in the mold. By this method, cases have been found where piles were exposed at the bottom, since nothing but gravel descended through the water to that depth and the teredo could enter the interstices between the grouting.

(5) An improvement to the concrete method of protecting wood is split vitrified pipes. They are placed around the piles and held in place by wires and then are filled with concrete. This method is expensive and it is not very efficient.

(6) Sewer pipe is strung over the top of the pile and filled with sand. This method overcomes the difficulty met by

concrete covering or filling, since the sand filling allows the sewer pipe to descend as the mud line recedes. The serious objections to this process are: (1) In old structures, caps of the piles must be removed before the sewer pipes can be placed, thereby it interferes with the speed of the construction of the new work, and also with the traffic when applied to old structures. (2) In order to repair one section of one pile, it is necessary to remove the cap from that entire unit.

(7) The most efficient device for wood pile protection is the new lock joint pipe, an improvement on the sewer pipe. It consists of sections of a concrete pipe cast in halves so that it may be bolted around a pile when it is already in position. The pipe is larger than the pile and the space between them is filled up with sand. Thus like the sewer pipe device, the lock joint pipe settles down as the mud line recedes and always keeping the pile protected throughout the field of attacks of the salt water wood boring animals. This device can be used with advantage to old structures as well as to the new, without removing the deck, without interfering with the traffic and without using the services of a diver.

IV. RENEWALS OF TIES.

The tie renewals are considered as being one of the important items in the expense account of the maintenance of way, and actually the average cost of the rail renewals on many roads is far less than that of the tie renewals. A few years ago the increased cost of the latter was but a fraction of the cost of the former, but at present the condition is just the reverse.

The constant increase of tie renewals is due to the following causes:

1. The price of timber is increasing.

2. Poorer qualities of timber are used for ties consequently giving insufficient service.

3. Spike-killing.

On some roads where metal tie plates are used, the yearly renewals of ties per mile is considerably less than that where all wooden ties are used.

V. STRENGTH OF TREATED TIMBER.

The strength of treated timber varies directly with the length of time seasoned and inversely as the amount of pressure, and the length of time under pressure.

The average of the results obtained from the test on Douglas Fir timber experimented at the Sacramento shops of the Southern Pacific Ry. and at the University of California showed that its modulus of elasticity when creosoted is 13 per cent less than when it is untreated. The former has also a decrease of 30 per cent in the outer fiber stress at elastic limit and at failure. The tendency to reduce in strength after it is creosoted is probably due to the method of treatment which is by boiling process, or it may be that the characteristics of the Douglas Fir are such that it will be weakened by treatment.

The tests of Loblolly pine beams at Purdue University showed a loss in strength of the material in bending of about 16 per cent, and in compression perpendicular to the grain about 29 per cent.

Tests by Prof. Talbot of the University of Illinois upon Loblolly pine beams show a reduction of 44 per cent in elastic limit and 30 per cent at maximum load. Other tests, however, show greater strength when treated.

From these tests and several other tests conducted up to the present, the following conclusion has been brought forward in regard to the effect of treatment on timber.

(A) With reference to small materials such as ties.

(1) High steaming diminishes the strength rapidly.

(2) Treating with strong solution of zinc chloride will make the timber brittle on account, perhaps, of free acid in the solution.

(3) Creosote oil is inert and it affects the transmission of moisture in or out of the wood.

(4) Seasoned timber treated with eight doses of creosote is as strong as the unseasoned timber.

(B) With reference to large bridge materials.

(1) The use of steam pressures of 40 lbs. to 50 lbs. reduces considerably the strength of timber.

(2) The internal checks which weaken the timber to shearing stresses are the results of internal strains caused by the thermal condition of the treatment.

(3) Heavily creosoted material is weak in compression at right angles to the grain.

(C) Treatment with crude petroleum may render the wood soft and weak.

Bending Tests on Beams Seasoned under Different Conditions.

Loblolly Pine. (8" x 16" section, 13½' to 15' span).

	No. of Tests	Fiber Stress at Elastic Limit lbs. per sq. in.	Modulus of Rupture lbs. per sq. in.	Longitudinal Shear at Max. Load lbs. per sq. in.	Modulus of Elasticity in thousands of lbs. per sq. in.	Percentage of Moisture	Rings per inch	Weight per cu. ft. Oven dry in lbs.	Conditions of Seasoning.
Average		3580	5480	364	1780	23.2	9.4	33.7	Air dry, 3½
Maximum	4	4070	6600	440	1987	24.3	11.5	34.5	months in the
Minimum		3090	5000	327	1530	21.5	8.0	32.5	open
Average		4512	5060	333	1685	20.0	7.7	33.9	Kiln dry 6
Maximum	5	5840	7320	488	1790	22.0	10.2	38.0	days
Minimum		3180	2150	143	1410	18.0	4.7	27.7	
Average		4331	6721	493	1688		7.7		Air dry, 21
Maximum	12	4990	8560	620	2002		9.5		months under
Minimum		3110	5160	380	1398		5.5		water

Table taken from tests conducted by Prof. W. H. Gregory at Tulane University of Louisiana.

Strength.

Maximum fiber stress in tension	Timber 3" x 3" x 36"
Untreated loblolly pine	4500 lbs. per sq. in.
Creosoted loblolly pine	3020 " " " "

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Horizontal Shear	Timber 1' long
Untreated loblolly pine (1)	403 lbs. per. sq. in.
" " " (2)	764 " " " "
Treated loblolly pine (1)	490 " " " "
" " " (2)	665 " " " "

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Average Horizontal Shear.	Timber 7" x 16" x 15'
Untreated loblolly pine	379 lbs. per. sq. in.
Creosoted loblolly pine	317 " " " "

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Table taken from tests made in the Engineering Experiment Station at the University of Illinois.

Strength.

	Per Cent.
Strength of unsteamed tie	100
" " tie steamed 4 hours at 10#	[illegible]
" " " " " " " 20#	84
" " " " " " " 30#	75
" " " " " " " 40#	76
" " " " " " " 50#	68
" " " " " " " 100#	41.

From the results given above, it is plain that timber which is subjected to steam pressure shows a loss in strength.

VI. EFFECT OF TREATMENT ON THE LIFE OF TIMBER.

The life of timber is without doubt increased by the use of preservative treatment. However, the added length of life can not be ascertained with accuracy and it simply depends on different factors such as the kind of wood, the kind of treatment given, the kind of preservative used, and the kind of service and climate in which the wood is to be subjected. The L. & N. R. R. Co. used in 1882 large quantities of creosoted piles, stringers and caps in the construction of trestles and docks in the vicinity of Pensacola, Florida, and all gave a service of twenty-five years. In the central west, hemlock and tamarack ties treated by the Wellhouse process gave a service of twelve to fourteen years, while untreated ties under the same conditions have shown a life of four years. At Girardville, Pa., in the Reading Coal Company's mine treated timbers have lasted for twelve years, while untreated timbers would not last more than two years. From the average estimates of treated and untreated life for the various forms throughout the United States and under all conditions the Forest Service has estimated that the life of ties properly treated will be increased over 200 %, of poles 100 %, of posts 300 %, of piles 700 %, of mine props 400 %, and of lumber 300 %.

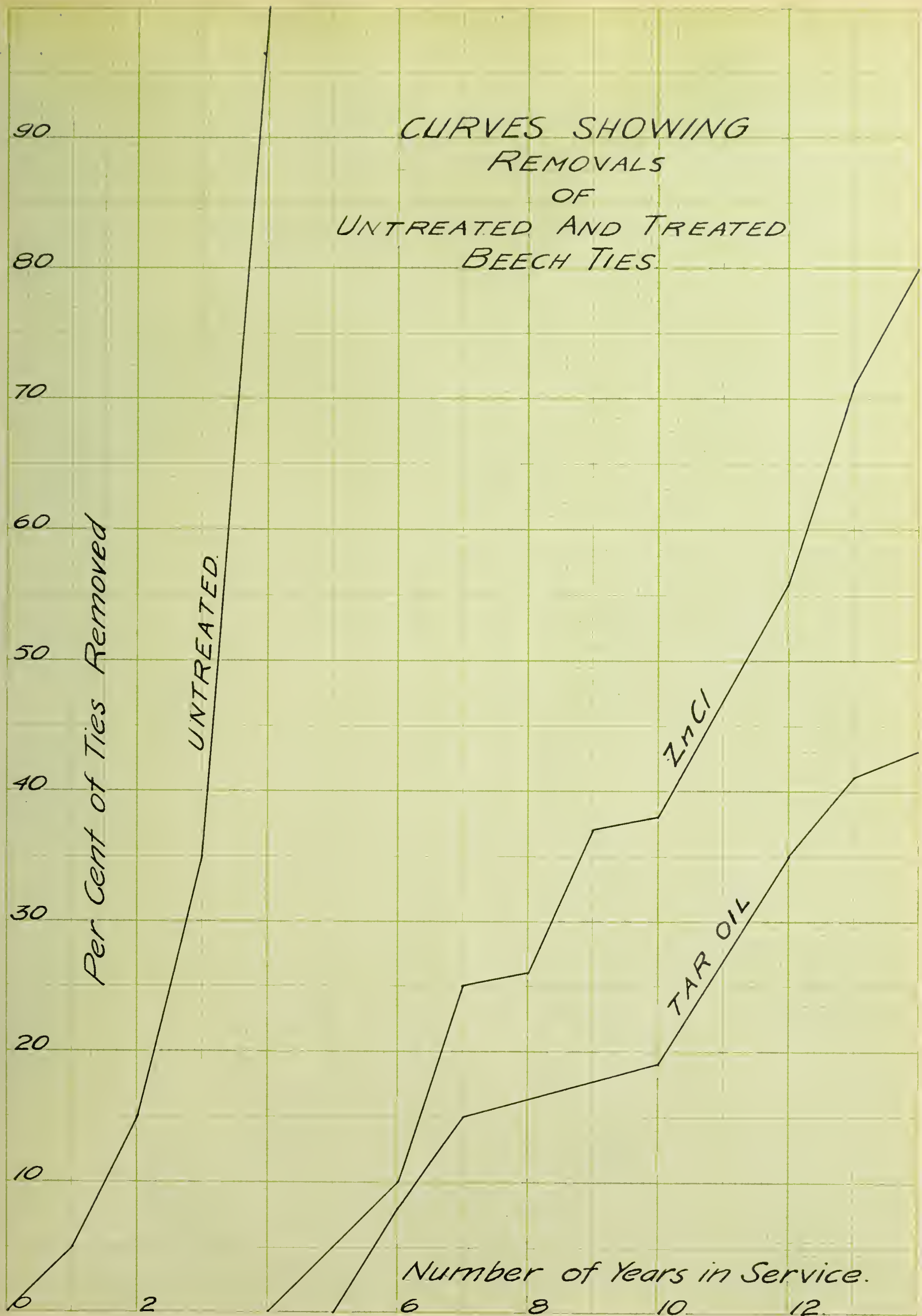
Treated Tie Record.

C. R. I. & P. R. R.

Sec.	No. of Ties	Renewed 1891 No.	Renewed 1891 %	Renewed 1892 No.	Renewed 1892 %	Removed 1893 No.	Removed 1893 %	Number in Track No.	Number in Track %	Per Cent Removed Average
1	8000	00	00	00	00	200	2.5	1488	18.6	71.1
2	8000	00	00	00	00	425	5.3	3137	39.2	
3	3150	00	00	00	00	67	2.2	1963	64.4	41.2
4	2800	00	00	00	00	0	0	1477	52.7	
				Natural Oak.						
1	10000	0	0	437	4.9	800	8.0	3134	31.3	74.1
2	10000	418	4.2	658	6.6	1070	11.[illegible]	1985	19.8	
3	15000	150	1.0	576	3.8	805	5.4	2732	18.2	74.5
4	15000	282	1.8	685	4.5	1235	8.2	4979	32.7	

Average Life of Treated Ties.

Section 1	10.27 years
" 2	11.15 "
" 3	10.34 "
" 4	11.62 "


CURVES SHOWING
REMOVALS
OF
UNTREATED AND TREATED
BEECH TIES
Per Cent of Ties Removed
Number of Years in Service.
UNTREATED
ZnCl
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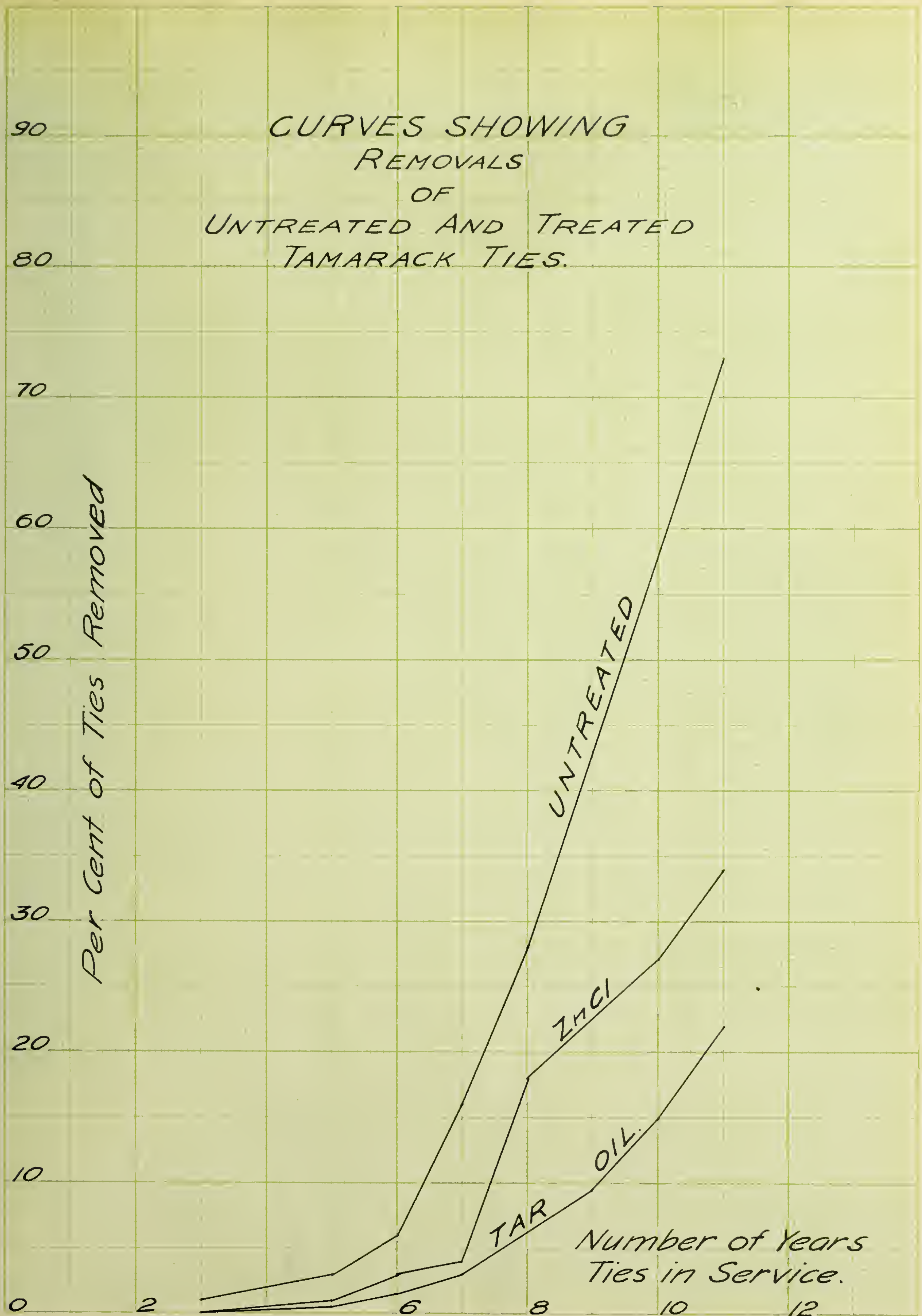
12



CURVES SHOWING
REMOVALS
OF
UNTREATED AND TREATED
TAMARACK TIES.
Per Cent of Ties Removed
Number of Years
Ties in Service.
UNTREATED
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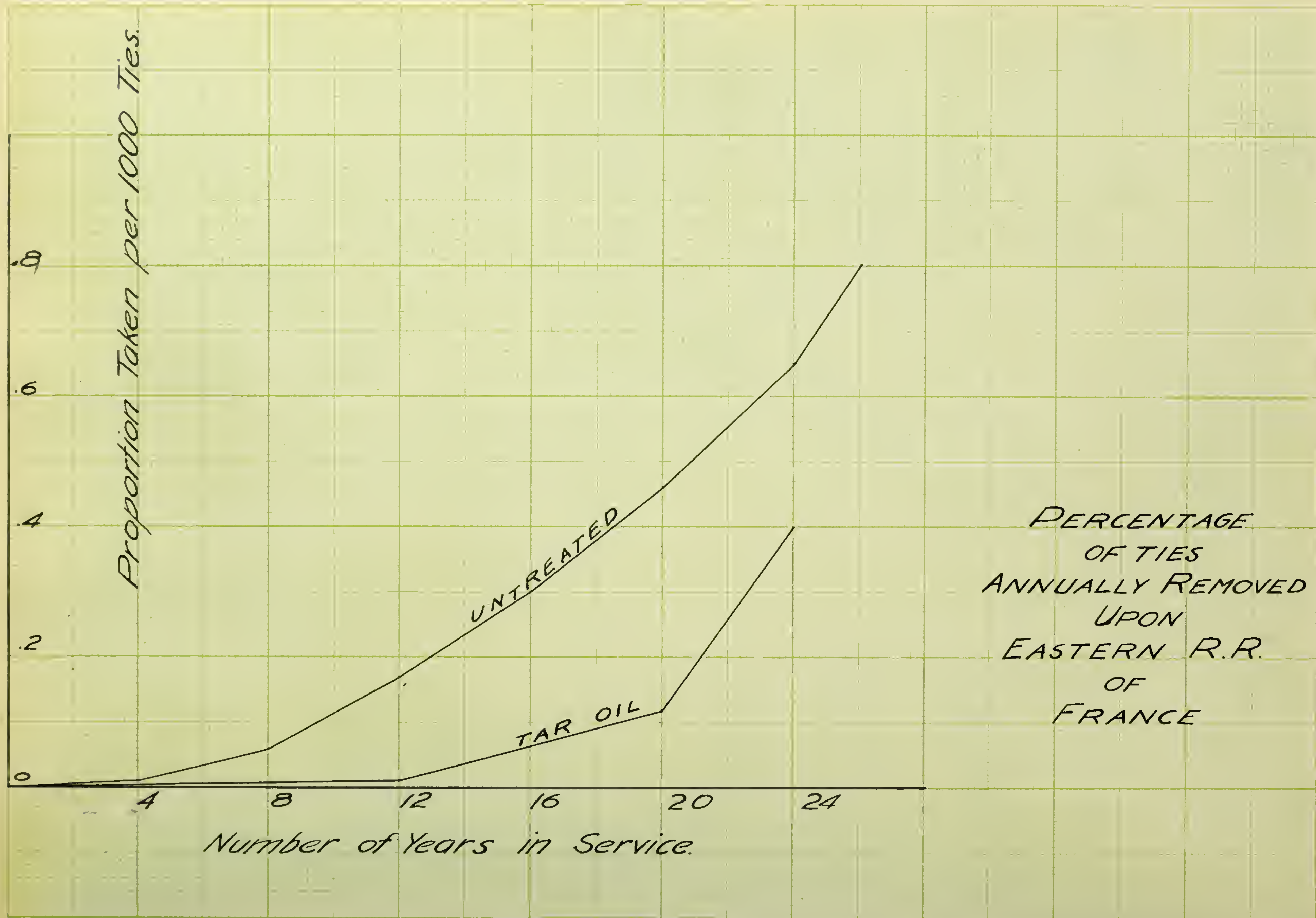
Proportion Taken per 1000 Ties.
.8
.6
.4
.2
0
UNTREATED
TAR OIL
4
8
12
16
20
24
Number of Years in Service.
PERCENTAGE
OF TIES
ANNUALLY REMOVED
UPON
EASTERN R.R.
OF
FRANCE

VIII. COST.

To compare the ultimate cost of treated timbers with that of the untreated timbers is a question to be resolved by a comparison between the annual charges made against those timbers. The factors involved are the original cost, length of life, cost of material, cost of renewal, and compound interest on the investment. The rate of interest can be neglected, since any comparison must be made at the same rate.

Let C = original cost of timber

n = Life of timber in years

A = Annual payment with compound interest which if placed aside will amount to a sum sufficient to replace (at cost of C) the timber at the end of n years

r = rate of interest on original cost.

For convenience of comparing the cost of timbers, a tie will be considered. A payment of C is made at the end of n years. The present value of this second payment is $\frac{C}{(1+r)^n}$. But the present value of the third payment which is made at the end of 2n years is $\frac{C}{(1+r)^{2n}}$. Then the total present value of the investment will be equal to $C + \frac{C}{(1+r)^n} + \frac{C}{(1+r)^{2n}} + \dots$.

Assuming a second annual payment A is made at the end of each year, the present value of these payments is as follows:

For the first payment $\frac{A}{(1-r)}$.

" " nth " $\frac{A}{(1+r)^n}$

The annual payments which represent the present worth of

the tie during its life of n years.

When the tie is replaced after n years, the value of the replaced tie will be:

For the (n+1) payment $= \frac{A}{(1+r)^{n+1}}$

For the 2n payment $= \frac{A}{(1+r)^{2n}}$

When this is replaced by a third tie the present value of the $3n^{th}$ payment against the third tie $= \frac{A}{(1+r)^{3n}}$

The value of the investment will equal the present value of the annual payments charged up against these ties as long as the series is continued, i.e.,

$$C + \frac{C}{(1+r)^n} + \frac{C}{(1+r)^{2n}} + - - - = \frac{A}{(1+r)} + \frac{A}{(1+r)^2} + - - - - + \frac{A}{(1+r)^n}$$

$$+ \frac{A}{(1+r)^{n+1}} + - - - - - - - + \frac{A}{(1+r)^{2n}}$$

$$+ \frac{A}{(1+r)^{2n+1}} + - - - - - - + \frac{A}{(1+r)^{3n}}$$

$$\frac{C\ (1+r)^n}{(1+r)^n-1} = \frac{A}{r} \qquad A = \frac{r \times C \times (1+r)^n}{(1+r)^n-1}$$

The annual charge A' against renewals must also be considered.

Let C' = cost of renewals

r' = rate of interest

$$A' = \frac{C' \times r}{(1+r)^n-1}$$

Cost.

Suppose a tie costs 80 cents and will last twelve years. If the rate of interest is 4 per cent, the annual charge

$$A = \frac{.04 \times 80 \times (1.04)^{12}}{(1.04)^{12} - 1} = \frac{.04 \times 80 \times 1.6010}{1.6010 - 1} = 8.50$$

The annual charge against renewals must also [illegible] taken into account. If the cost of relaying the tie is [illegible] cents the annual charge is 1.33 cents. Then the total annual charge against the tie in question is equal to [illegible] + 1.33 = [illegible].

From the report of Gilbert [illegible] on Methods and Technical Aspects of Modern Timber Preservation.

VIII. ECONOMIC CONSIDERATION.

The first and most important factor which leads to prolonging the life of timber by the use of preservative treatment is the economy. Neglecting the interest charges, the cost of treating a tie which will last four years without the use of preservatives, is always less than the additional cost of new timber four years later, plus the cost of laying. However, if treatment is carried on large scale, the cost does not always exceed the price of timber. Thus, the financial saving is equal to the cost of laying plus the increase in price of timber over four years. More frequently, proper method of preservation increases the life of timber three times or four times and the saving is correspondingly greater. Another factor which makes the treatment of wood applicable, is that replacement of timber is not only an expensive undertaking but also it interferes with the work in progress and hence it gives rise to serious financial loss.

In the report of [illegible], U. S. Forest Service of Agriculture, he states that by proper preservative treatment and the prevailing rate of interest, it can be estimated that the net annual saving for each treated form would be 3 cents for a tie, 9 cents for a pole, 1 cent for a post, 2 cents for mine props, and about 50 cents for every one thousand feet of lumber. The three economic objects accomplished by the use of wood preservation are as follows:

1. It increases the life of durable species.
2. It prolongs the life of inferior or cheaper timbers which when untreated would have little or no value.

5. It removes [illegible]

and [illegible] saved can be used for other purposes.

IX. CONCLUSION.

One of the chief factors which tends to increase the knowledge on wood-preserving devices in this country is the conservation of the forest resources by reducing the amount of consumption. United States is at present facing a threatened timber famine and is paying high prices for poorer wood materials. These can in one way be averted by successful wood preservation.

Today, creosoting is the best method though somewhat expensive, of prolonging the life of timber and it is the only chemical preservative now practiced, that can protect the piles from the dangerous attacks of teredo and other salt water boring animals. Structural engineers have always used creosoted materials for all structural timbers exposed to weather. However, in the southern states very little amount of creosoted material has been used for piling, but it is to be hoped that the time will soon come when the greater portion of timber consumption will be creosoted. A better process than creosoting which was recently introduced is called the "neutral processes". Its possibility for commercial purposes has lead a great many engineers to carry on experiments, and I believe that the time is not far distant when neutral processes will come into extensive use.

In conclusion it can be said that at no time have we had a greater cause to look upon the past with satisfaction and upon the future with expectancy. Engineers of today have seldom failed to obtain satisfactory results from their works based upon theory which is supported by little or no experience. Thus, we are on a firm working basis and are ready to appraise new methods

in accordance with their value and we may adopt them [illegible] [illegible] hope that they will be a thorough solution of the road-improving problem.

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